

Nokia Customer Care NEM-4 Series Cellular Phones

7 – Baseband

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List of Abbreviations

ADSP	Application DSP, TMS320DA250
AIC	Audio Codec for Amadeus, manufactured by TI
ASIC	Application Specific Integrated Circuit
BB	Baseband
BLUETOOTH, BT	Bluetooth
BSI	Battery Size Indicator
CBus	Control Bus connecting UPP_WD2 with UEM
CPU	Central Processing Unit
DBUS	Data Bus
DSP	Digital Signal Processor
EGSM	Extended – GSM
GPRS	General Packet Radio Service
GSM	Group Special Mobile/Global system mobile
HF	Hands free
HFCM	Handsfree Common
HS	Handset
I/O	Input/Output
IHF	Integrated hands free
IR	Infra red
LCD	Liquid Crystal Display
MCU	Micro Controller Unit
MIC, mic	Microphone
PDA	Pocket Data Application
PWB	Printed Wiring Board

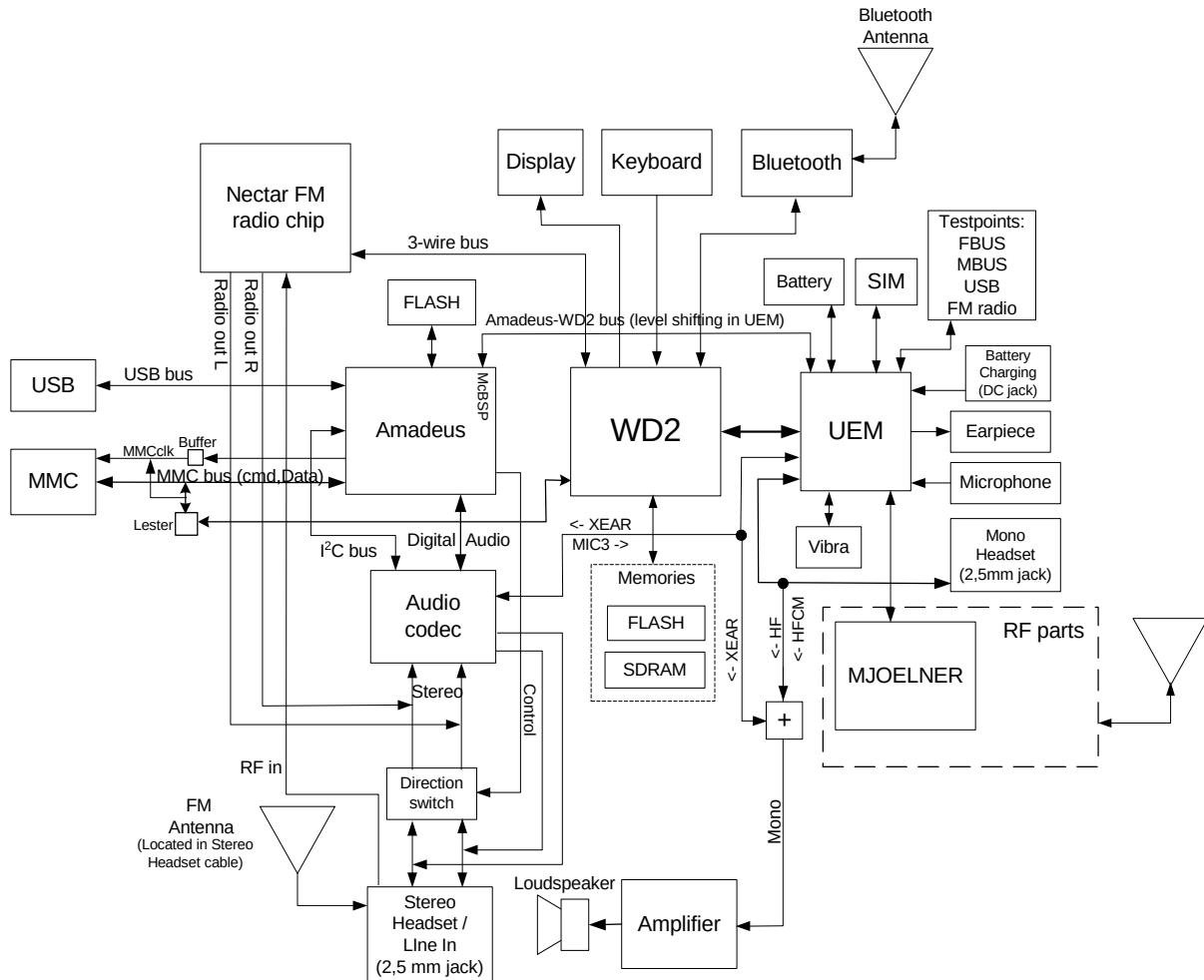
RF	Radio Frequency
RFBUS	Control Bus For RF
SDRAM	Synchronous Dynamic Random Access Memory
SIM	Subscriber Identity Module
UI	User Interface
UEM	Universal Energy Management
USB	Universal Serial Bus
VCXO	Voltage Controlled Crystal Oscillator
VGA	Video Graphics Array

NEM-4 Block Diagram

NEM-4 product consists of RF, BB, Bluetooth and audio blocks.

External interfaces of NEM-4 consist of Bluetooth, stereo and mono headsets, charger as well as the Universal Serial Bus (USB).

Figure 1: NEM-4 Block Diagram



Baseband Technical Summary

Baseband is basically constructed around three main ASICs or chips: UPP_WD2 (engine ASIC with MCU, DSP and Digital Control Logic), UEM (handles e.g. power management, charging and part of the external interfaces) and ADSP (audio processing). Discrete regulators are also used for powering.

Memory comprises of 3 x 64Mbit flash memory devices and 128Mbit (16Mbytes) SDRAM.

For data connectivity there are Bluetooth, USB and MMC card.

The display is an MD-TFD LCD panel module with 4096 colours and 176x208 pixels with backlighting. The keypad is a gaming keypad with a rocker and shortcut keys.

The audio part includes ADSP for audio processing and controlling, AIC audio codec and Nectar FM radio chip. There are two audio transducers (Earpiece 8mm and IHF speaker 16mm) and external interface for stereo and mono headsets. The IHF speaker produces the ring tone. The IHF speaker is driven by a discrete audio amplifier.

Functional Description

BB description

The BB core is based on UPP_WD2 CPU, which is a PDA version of the DCT4 UPP ASIC. UPP_WD2 takes care of almost all of the signal processing and operation controlling tasks of the phone as well as all PDA tasks. UPP_WD2 controls also controls ADSP and Nectar audio chips. ADSP handles MP3 processing, USB-MMC functionality and AIC control.

UPP_WD2-ADSP data transmission is implemented with asynchronous two-signal bus, routed via level shifter in UEM ASIC. Nectar FM-radio chip is controlled by UPP_WD2 via I2C bus.

For power management there is one main ASIC for controlling charging and supplying power UEM plus some discrete power supplies. The main reset for the system is generated by the UEM.

The interface to the RF and audio sections is also handled by the UEM. This ASIC provides A/D and D/A conversion of the in-phase and quadrature receive and transmit signal paths and also A/D and D/A conversions of received and transmitted audio signals. Data transmission between UEM and RF and the UPP_WD2 is implemented using different serial connections (CBUS, DBUS and RFBUS). Digital speech processing is handled by UPP_WD2 ASIC.

A real time clock function is integrated into UEM, which utilizes the same 32kHz-clock source as the sleep clock. A rechargeable battery provides backup power to run the RTC when the main battery is removed. RTC Backup time is 7 hours.

Memory configuration

NEM-4 uses two kinds of memories, flash and SDRAM. These memories have their own dedicated bus interfaces to UPP_WD2. The SDRAM size is 128Mbits (4M x 16).

Synchronous DRAM is used as working memory. Interface is 16 bit wide data and 14 bit Address. Memory clocking speed is 104 MHz.

All memory contents are lost if the supply voltage is switched off.

Multiplexed flash memory interface is used to store the MCU program code and user data. The memory interface is a burst type FLASH with multiplexed address/data bus, running at 104/3MHz.

SDRAM I/O and core are supplied 1.8V by UEM regulator VIO and discrete regulator

VMEMA respectively.

Energy management

The master of EM control is UEM and with SW this has the main control of the system voltages and operating modes.

Modes of operation

NEM-4 employs several hardware & SW controlled operation modes. Main modes are described below.

- NO_SUPPLY mode means that the main battery is not present or its voltage is too low (below UEM master reset threshold) and back-up battery voltage is too low.
- In BACK_UP mode the main battery is not present or its voltage is too low but back-up battery has sufficient charge in it.
- In PWR_OFF mode the main battery is present and its voltage is over UEM master reset threshold. All regulators are disabled.
- RESET mode is a synonym for start-up sequence and contains in fact several modes. In this mode regulators and oscillators are enabled and after they have stabilized system reset is released and PWR_ON mode entered.
- In PWR_ON mode SW is running and controlling the system.
- SLEEP mode is entered from PWR_ON mode when the system's activity is low (SLEEPX controlled by SW).
- FLASHING mode is for production SW download.

Voltage limits

In the following the voltage limits of the system are listed. These are also controlling system states.:

Parameter	Description	Value
V _{MSTR+}	Master reset threshold (rising)	2.1 V (typ.)
V _{MSTR-}	Master reset threshold (falling)	1.9 V (typ.)
V _{COFF+}	Hardware cutoff (rising)	3.1 V (typ.)
V _{COFF-}	Hardware cutoff (falling)	2.8 V (typ.)
V _{BU_{COFF+}}	Back-up battery cutoff (rising)	2.1 V (typ.)
V _{BU_{COFF-}}	Back-up battery cutoff (falling)	2.0 V (typ.)
SW _{COFF}	SW cutoff limit (> regulator drop-out limit) MIN!	3.4 V SW changeable

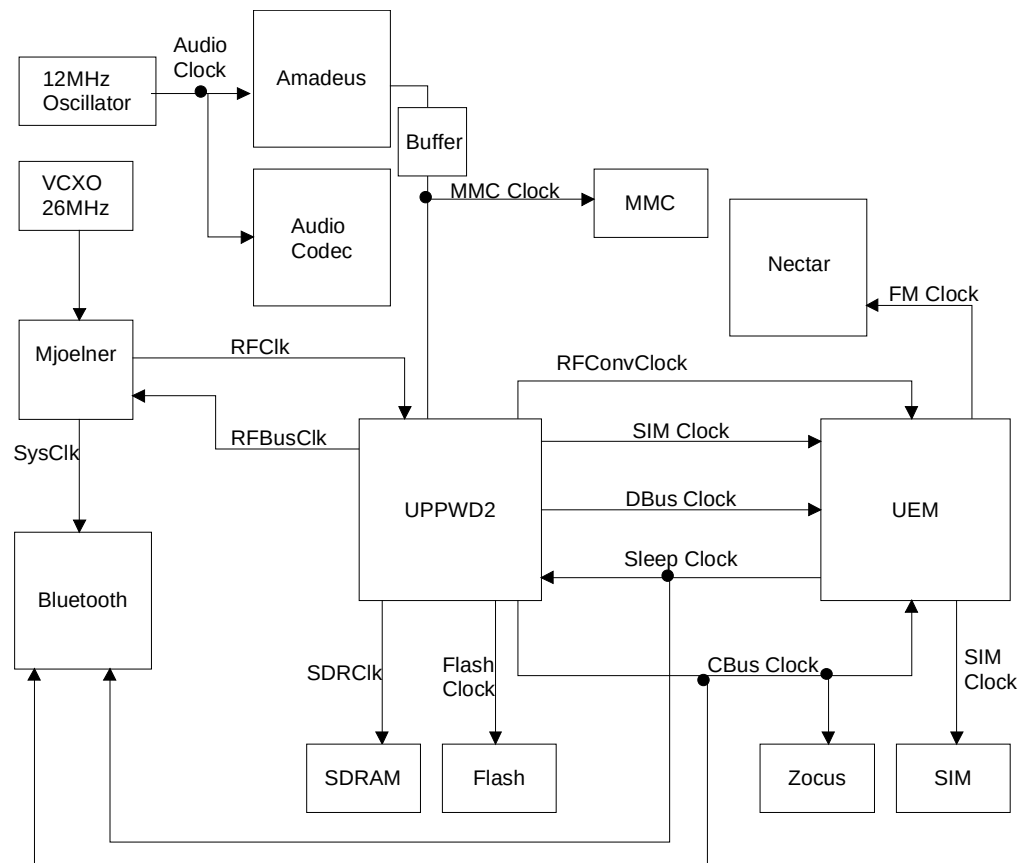
The master reset threshold controls the internal reset of UEM. If battery voltage is above V_{MSTR} , UEM's charging control logic is alive. Also, RTC is active and supplied from the main battery. Above V_{MSTR} UEM allows the system to be powered on although this may not succeed due to voltage drops during start-up. SW can also consider battery voltage too low for operation and power down the system.

Clocking scheme

A 26 MHz VCXO is used as system clock generator in GSM. During the system start-up, UEM RC-oscillators generate timing for state machines. All clock signals of the engine are illustrated in following figure.

Bluetooth uses 26 MHz clock.

Figure 2: NEM-4 Clocking.



In SLEEP mode the VCXO is off. UEM generates low frequency clock signal (32.768 kHz) that is fed to UPP_WD2, Bluetooth and ZOCUS.

ADSP and AIC use a 12 MHz clock (audio clock) generated by external oscillator. The Audio clock is on when ADSP is powered.

UPP_WD2 voltage/clock frequency adjusting

No external clock is available for UPP_WD2 before VCXO starts. As reset is released, the VCXO is running and MCU uses the 26 MHz clock while DSP is in reset. There are three identical DPLL's, for MCU, for DSP and for accessory interfaces, which can be controlled

independently. The clock for MCU can be up to 104 MHz and 117 MHz is maximum clock frequency for the DSP. These clock signals are used either directly (SDRAM IF) or divided down for the interfaces (e.g. flash IF).

Power distribution, control and reset

All power (except backup battery power) is drawn from BL5-C Li-Ion battery located in the B cover. Current flows through ZOCUS current sense resistor which is used for current measurement by ZOCUS and thus for remaining operating time estimation.

EM4 board contains one power ASIC, UEM and discrete regulators needed for generating the different operating voltages. The discrete regulators consist of two SMPSs and four linear regulators. Two SMPSs are used to power UPP_WD2 core voltage and SDRAM core voltage. Three linear regulators power 3.1V for ADSP and AIC audio converter. One 1.5V linear regulator is used for ADSP core voltage. In addition there is a SMPS in EM4 generating the operating voltage for display module backlighting.

Power-up sequence (reset mode)

RESET mode can be entered in four ways: by inserting the battery or charger, by RTC alarm or by pressing the power key. The VCXO is Powered by UEM. After a 220 ms delay regulators are configured and UEM enters PWR_ON mode and system reset PURX is released.

During system start-up, in RESET state, the regulators are enabled, and each regulator charges the capacitor(s) at the output with the maximum current (short circuit current) it can deliver. This results in battery voltage dropping during start-up. When a battery with voltage level just above the hardware cutoff limit is inserted, the system may not start due to excessive voltage dipping. Dropping below 2.8 V for longer than 5 us forces the system to PWR_OFF state.

Powering off

Controlled powering off is done when the user requests it by pressing the power key or when the battery voltage falls too low. Uncontrolled powering off happens when the battery is suddenly removed or if over-temperature condition is detected in regulator block while in RESET mode. Then all UEM's regulators are disabled immediately and discrete regulators are disabled as Vbat supply disappears.

Controlled powering off

For NEM-4 powering off is initiated by pressing the power key and Power off sequence is activated in UEM and SW. Basically, the power key causes UEM interrupt to UPP_WD2 and SW sets the watchdog time value to zero and as this happens, PURX is forced low and all regulators are disabled.

If the battery voltage falls below the very last SW-cutoff level, SW will power off the system by letting the UEM's watchdog elapse.

If thermal shutdown limit in UEM regulator block is exceeded, the system is powered off. System reset PURX is forced low.

Uncontrolled powering off

This happens when the battery is suddenly removed. UEM's state machine notices battery removal after battery voltage has been below V_{COFF-} for 5 us and enters PWR_OFF mode. PURX is set low and all UEM's regulators are disabled.

Watchdogs

There are three watchdogs in UEM. The first one is for controlling system power-on and power-down sequences. The initial time for this watchdog after reset is 32 s and the watchdog can not be disabled. The time can be set using a register. This watchdog is used for powering the system off in a controlled manner. The other one is for security block and is used during IMEI code setting. The third one is a power key watchdog. It is used to power off the system in case SW is stuck and the user presses the power key. This WD is SW configurable.

There is also a "soft watchdog" in UPP_WD2. It is used to reset the chip in case software gets stuck for any reason. The Bluetooth module also contains a watchdog.

Charging

Charging control and charge switch is in UEM. There are two different charging modes; charging empty battery (start-up charge mode), and SW controlled charging.

UEM digital part takes care of charger detection (generates interrupt to UPP_WD2), pulse width modulated charging control (for internal charge switch) and over voltage and current detection. SW using registers controls all these.

Chargers

NEM-4 BB supports a standard charger (two wires), chargers ACP-8 and ACP-12, cigarette charger LCH-8 and LCH-12 are supported.

Battery

NEM-4 battery is a detachable, semi-fixed Lithium-Ion BL5-C battery. Nominal voltage is thus 3.7 V (max charging voltage 4.2 V).

The interface consists of three pins: VBAT, GND and BSI. Pull-down resistor inside of the batteries (BSI signal) recognizes the battery types. Voltage level at BSI line is measured using UEM's AD-converter.

Back-up battery and real time clock

Real time clock (RTC), crystal oscillator and back-up battery circuitry reside in UEM. A register in UEM controls back-up battery charging and charging is possible only in POWER_ON State.

Baseband measurement A/D converter

UEM contains 11 channels A/D converter, which is used for different baseband measurement purposes. The resolution of A/D converter is 10 bits. Converter uses the CBUS interface clock signal for the conversion. An interrupt will be given to the MCU at the end of

the measurements. The Converter is used for following purposes.

- Battery Voltage Measurement A/D Channel (Internal)
- Charger Voltage Measurement A/D Channel (Internal)
- Charger Current Measurement A/D Channel (Internal)
- Battery Temperature Measurement A/D Channel (External)
- Battery Size Measurement A/D Channel (External)
- LED Temperature measurement A/D Channel (External)

There is also auxiliary AD converter in UEM, which is used to monitor RF functions.

ZOCUS

The ZOCUS device is a current sensor used for the battery bar display and for determining whether the phone is in a high current consuming mode. The ZOCUS device measures the voltage drop across a sense resistor in the battery voltage line. This sense resistor is formed from a PWB track and is on an internal layer of the PWB. The sense resistor must be located close to the battery terminals so that all of the phones current flow through it. The nominal value of the sense resistor is 3.3 mohm. ZOCUS reports the current measurement to UPP_WD2 via the Cbus interface.

NEM-4 BB Features, HW Interfaces and User Interface

Display and keypad

The UI-module consists of the LCD and keymat. The NEM-4 display resolution is 176 x 208 and backlighting is via 4 white LEDs with lightguide. The display is connected to EM4 board with 16-pin connector. The keypad is of gaming type and is backlit with 10 LEDs. The keymat interfaces with UPP_WD2 GPIO/GENIO pins.

Bluetooth

Bluetooth provides a fully digital link for communication between a master unit and one or more slave units. The system provides a radio link that offers a high degree of flexibility to support various applications and product scenarios. Data and control interface for a low power RF module is provided. Data rate is regulated between the master and the slave.

SIM interface

The SIM interface is located in two chips (UPP_WD2 and UEM). In UEM there is only support for one SIM card. The interfaces support both 1.8 V and 3 V SIM cards. Adjustable SIM regulator (1.8V/3.0V) is located in UEM and can be controlled by SW.

The data communication between the card and the phone is asynchronous half duplex.

The clock supplied to the card is 3.25 MHz. The data baudrate is SIM card clock frequency divided by 372 (by default), 64, 32 or 16.

MMC interface

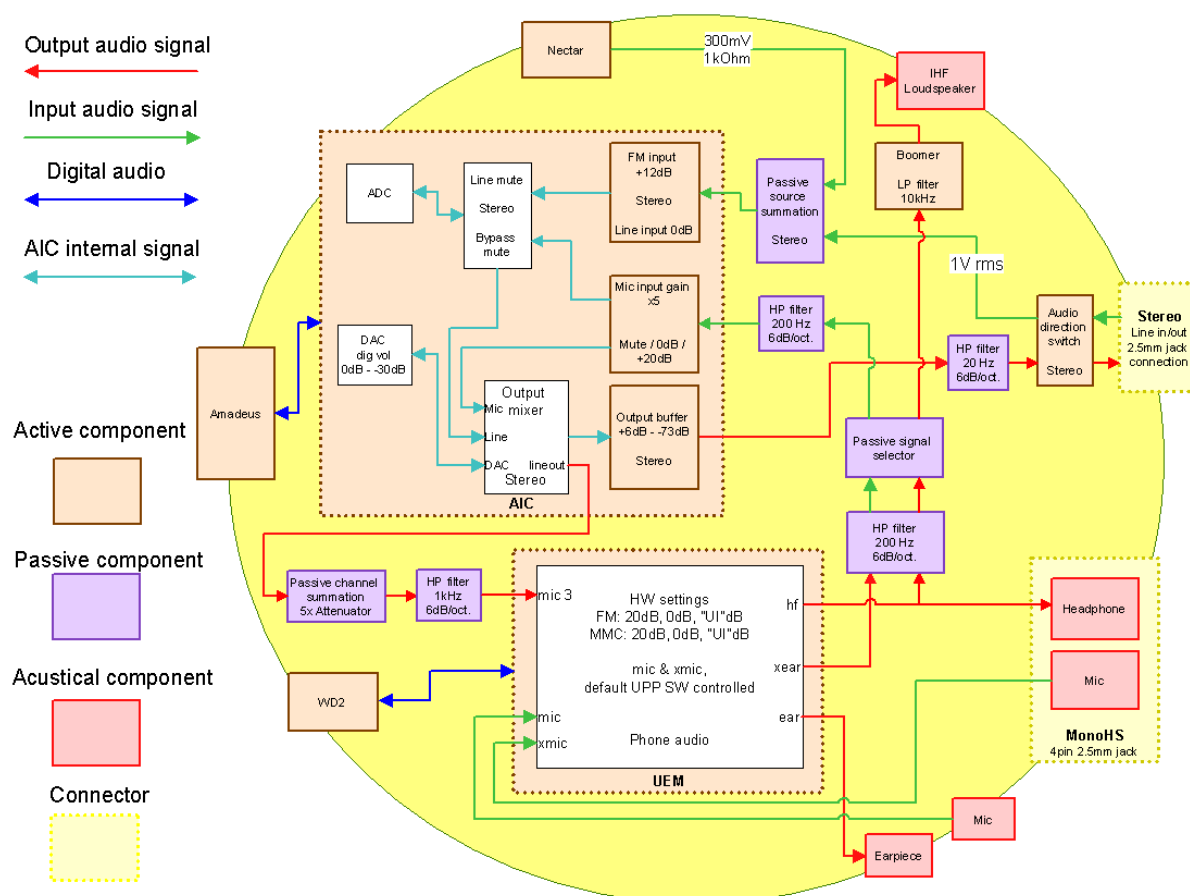
MMC is interfaced with UPP_WD2 and ADSP. Both UPP_WD2 and ADSP have MMC interfacing functionality integrated to the chip. The MMC interface comprises of three lines: clock, data and command and runs at 8.66MHz. There is EMC protection ASIP for MMC as well as a level shifter (Lester) for UPP_WD2 MMC signals and a buffer for ADSP MMC clock line. The Lester device also incorporates a 2.85V regulator to the MMC card.

NEM-4 audio concept

NEM-4 audio includes earpiece, microphone, stereo headset connector, Mono headset connector, Integrated Handsfree (IHF). Audio is based on UPPWD2 phone engine ASIC, ADSP Application DSP, AIC Audio Codec, Nectar FM Radio and several discrete components including amplifier for IHF called Boomer.

Also UEM ASIC is used for many audio tasks. NEM-4 audio block diagram is presented in figure below.

Figure 3: NEM-4 Audio Block Diagram.



ADSP

The Application DSP (ADSP) is responsible for MP3/AAC decoding, AAC encoding, play-

back and recording the audio data stream as well as equalizing the playback from MP3/AAC audio data and FM radio. This part generates the ringing tones and controls the ringing tone power amplifier.

Audio routing and conditioning

The analog audio sources, FM radio and line in, are mixed and level conditioned in a passive stereo mixer and then fed through the Audio Codec RLINEIN and LLINEIN. The GSM downlink from the UEM HFOUT for headset is routed through the codec mono analog input (MICIN).

Source selection is controlled by software using the mute function for GSM downlink and power on/off for FM radio. FM radio is powered off when not in use for power saving. Disabling the output stage of the UEM mutes the GSM downlink signal. Line in signal is the master signal and cannot be muted.

Stereo headset detection is done via sense line from the 2.5mm jack connector to UPP_WD2 GENIO22.

The amplification and routing of the analog audio sources and outputs of the audio codec (AIC) is done via the control interface (SDIN, SCLK, CS, MODE) and the digital audio interface (DIN, LRCOUT, DOUT, BCLK) from ADSP.

Audio signal routing is done by software. The hardware concept is fixed wired. Only exception is the direction switch, that is used route line in audio from Stereo HS to AIC, and to route FM radio signal via AIC when radio is listened. Direction switch is controlled by ADSP GPIO6. The software manages the sources/inputs and the outputs that will be connected for the used path. Level and volume control, the equalizing for the selected path etc. are also controlled by software.

When recording from FM radio or line in, the signal can be monitored via IHF. A phone call during recording is not possible.

The following sections give an overview of the audio use cases.

FM radio play

In this case, AIC is doing the AD and the DA conversions and ADSP is responsible for gain setting and equalizing functions.

FM radio/line in recording

In this case, ADSP is responsible for encoding the digital audio signal. If the FM radio is chosen as source, the gain setting by 12dB is done by ADSP as well.

MP3/AAC playback

In this case, ADSP is working as decoder for digital audio stored on the MMC.

GSM audio handsfree mode

In handsfree mode, only the PA in the codec is used to drive the headset. The external

audio PA (Boomer) will be activated if the IHF loudspeaker is used for IHF mode.

Standard ringing tones / alarm tones

The routing for playing ringing or alarm tones is the same like in GSM handsfree mode.

MP3/AAC/MIDI ringing tones

If MP3/AAC files are used as ringtone, the routing corresponds to the routing in MP3/AAC playback mode.

MultiMediaCard MMC

NEM-4 uses a MMC as memory for the MP3/AAC files as well as games and other multi-media files. Records from line in or FM radio can be saved on this card. Also music files via USB can be stored on the MMC. The MMC is located under the battery and can be easily changed by the end user.

MMC can be accessed by both ADSP and UPPWD2. MMC interface includes CLK, CMD and DAT0 lines.

MMC power is supplied by additional 2.8V regulator integrated on same package with MMC level shifter (Lester). Lester does the level shifting for UPPWD2-MMC signals, and is controlled by UPPWD2 ASIC.

MMC CLK line between ADSP and MMC is buffered and the buffer is controlled by UEM.

ADSP flash memory

ADSP code and data is stored in a 16Mb, 16 bit wide asynchronous flash memory.

Acoustics

The following chapters give a description of acoustical parts.

Earpiece

The internal earpiece is a dynamic earpiece with an impedance of 32 ohms. The earpiece is low impedance one since the sound pressure is to be generated using current and not voltage as the supply voltage is limited to 2.7V.

The earpiece is driven directly by the UEM and the earpiece driver in UEM is a bridge amplifier.

Microphone

The internal microphone capsule is embedded into the chassis. Microphone is omnidirectional. The internal microphone is connected to the UEM microphone input MIC1P/N. The microphone input is asymmetric and microphone bias is provided by the UEM MIC1B. The microphone input on the UEM is ESD protected. Spring contacts are used to connect the microphone contacts to the engine PWB.

Loudspeaker

The loudspeaker in NEM-4 is used to generate alerting, ringing and warning tones. It is

also used as Integrated Handsfree (IHF) Speaker and as speaker for media playback (MP3, AAC, FM Radio).

Speaker capsule is embedded into the chassis. Spring contacts are used to connect the speaker contacts to the engine PWB.

Headset

The headset is of passive type with mono and stereo connectors as well as integrated microphone with answer key. The type name is HDD-2.

FM radio

The FM radio in NEM-4 is a single chip electronically tuned FM stereo radio with fully integrated IF selectivity and demodulation. It can be tuned to European, US and Japanese FM bands. The channel tuning and bus data are controlled by UPP via I2C bus (SDA, SCL and W/R signals). FM radio is only working when headset is connected because the cable is used as FM antenna.

Flashing

SW download in service is implemented by custom tools and SW, kindly refer to Service Software Instructions and Service Tool section of the manual.

Testing interfaces

Testing interface electrical specifications

Pin	Name	Dir	Parameter	Min	Typ	Max	Unit	Notes
1	MBUS	<->	Vol	0	0.2	0.3*VFlash1	V	
			Vil (From Prommer)	0	0.2	0.3*VFlash1	V	
			Voh	0.7*VFlash1	2.7	0.7*VFlash1	V	
			Vih(From Prommer)	0.7*VFlash1	2.7	VFlash1	V	
2	FBusTx	->	Vol	0	2.7	0.3*VFlash1	V	
			Voh	0.7*VFlash1	2.7	VFlash1	V	
3	FBusRx	<-	Vil (From Prommer)	0	2.7	0.3*VFlash1	V	
			Vih(FromPrommer)	1.89	2.7	VFlash1	V	
			Abs. Max. Voltage to Test Pad Referenced to GND	-0.3V		3.0	V	Absolute Max Voltage limits to MBUS/ FBUS
4	VPP		To Phone	0 / 2.8 / 12 +/-3%	V	Prommer Select	4	VPP
4	VPP		To Phone	0 / 2.8 / 12 +/-3%	V	Prommer Select	4	VPP
5	GND				0		V	VBAT GROUND

Note1: VFlash1 is 2.78 +/- 3%

Electrical specifications for power supply interface in prod testing

Pin	Name	Min	Typ	Max	Unit	Notes
1	VBAT	0	3.6	5.1	V	
2	BSI	0	2.78	VFlash1	V	Internal pullup
3	GND	0			V	

Note 1: VAna & VFlash1 = 2.78 +/-3%

Extreme voltages

Lithium-Ion battery BL-5C (1 cell):

Nominal voltage is 3.7V

Lower extreme voltage is 2.8V (cut off voltage)

Higher extreme voltage is 4.2V (charging high limit voltage)

Temperature conditions

Specifications are met within range of -10C to +55C ambient temperature. Reduced operation between [-30] and [+60]. Storage temperature range is of -40C to +85C.

Humidity and water resistance

Relative humidity range is 5 ... 95%. Condensed or dripping water may cause intermittent malfunctions. Protection against dripping water has to be implemented in (enclosure) mechanics. Continuous dampness will cause permanent damage to the module.